The (Dr. Matthew) Walker Texas Rangers III
(Zoha Malik, Alvin Mukalel, Cole Pickney, John (Sungho) Suh, Colin Sweeney)

Revised project objective statement: Develop a smart-shunt design for hydrocephalus treatment which detects proximal failure through measurement of differential pressure between the shunt and the brain and communicates this failure via near field communication to a smartphone external to the body.

Achievements since last report: We successfully cured PDMS at three different ratios (5:1, 10:1 and 15:1), with and without the strain gauge embedded. The strain gauge version will be used in our final prototype and also for strain gauge calibration at each PDMS level. We successfully acquired 10 shunt tubings from Dr. Feldman and started practicing cutting windows in the distal portions. We also received more strain gauges (20) from Omega Engineering along with their bridge completion modules. The strain gauge output upon pressure application was in the order of microvolts, so we constructed an amplification circuit using an Arduino as the 5V input and INA125P differential op amp. We successfully got voltage outputs in 100's of millivolts upon applying pressure to the strain gauge. We then began calibrating the strain gauge's output to pressure by immersing it in a water column and changing the water column height from 15 to 0 mmHg (P=rho*g*h). On the communication side, we finally received the level shifter required to write to our NFC chip. Using the Android app called "NFC Reader" we were able to read messages from the NFC tags written by the Arduino. The Arduino writes messages using the NDEF format, which the NFC Reader app is able to read.

Problems that have arisen: Our INA125P op amp blew up initially, and our next order for op amps got delayed by 4 business days. This added delay in our testing. Secondly, once we started the strain gauge calibration in the water column, we noticed that when the height of the column became shorter (under 10 mmHg), the pressure was not enough to keep the strain gauge pressed down, and it shifted and became tilted instead of remaining perfectly horizontal. So, we are in the process of planning a calibration experiment which overcomes this issue.

Work that lies ahead: Firstly, we have to complete our strain gauge calibration. We have decided to use the PDMS embedded strain gauge in the water column for this purpose. Gluing the PDMS onto the stage will ensure the strain gauge remains horizontal even when the water column pressure becomes smaller. The physiologically relevant critical calibration range will be 0-5 mmHg. We will perform the calibration for all three PDMS windows we have constructed. We will build three prototypes by embedding the PDMS/strain-gauge windows into the shunt tubing for the three stiffness levels. These prototypes will be tested by blocking all holes using parafilm, holding the proximal tips horizontally in the water column (similar set-up as the calibration experiment) and noting changes in voltage output as pressure is applied. The stiffness level which leads to the highest voltage output will be selected. On the communication end, the NFC message is able to be read remotely, however some additional filtering is needed from the Arduino. Once calibration of the strain gauge is completed, further data processing from the Arduino in conjunction with a message format needs to be determined.

Assessment of meeting schedule: We believe we will be able to design a prototype for proof of concept by design day. While we do not have the tools or skills to embed the wiring and circuitry inside the shunt, we should still be able to show that the strain gauge can (hopefully) detect the differential pressure that arises due to simulated proximal failure. We are also hopeful that we will be able to demonstrate that the voltage output, translated into pressure readings, can be written to the NFC chip and picked up by a smartphone.